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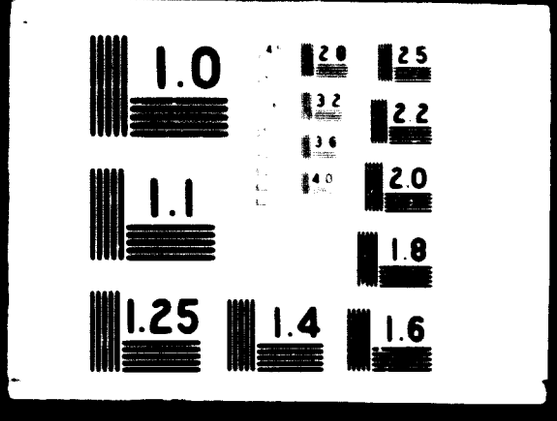

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FISHERIES INDUSTRIES

Prepared for the Symposium

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Summary and conclusions

1. With certain exceptions, such as dried fish, animal protein foods are generally more costly than vegetable protein foods. Also, readily available fish is usually the cheapest form of animal protein. Fishery industries development, therefore, has particularly great potential for bringing about a rapid improvement of the quality of the diets of the population of many developing countries. Furthermore, if present growth rates of population and agricultural production are projected into the more distant future, fisheries are likely to play an increasing role in food supplies throughout the world. Today, fish still makes only a relatively modest contribution to diets. In some developing countries, notably in the Far East, however, it accounts for the bulk of animal protein consumption.

2. A large share of the substantial increase in world catches in recent years has been accounted for by fisheries for raw material for industrial products, largely animal feeds. While use for feedstuffs makes a smaller nutritional contribution than fish used directly for human consumption, it indirectly adds to human food supplies. Much fish goes into reduction that, under present conditions, would not find other markets. Reduction industry products may increase their relative share of the future fisheries market, both because of the further spread of scientific farming methods, and because of a breakthrough in the development of nutritionally acceptable, inexpensive, protein concentrates for human consumption, which could help in the solution of malnutrition problems of developing areas. Today the principal product of the reduction industry, fish meal, is used primarily in the farming operations of industrialized countries. A large share of supplies has been imported in recent years from developing countries where the animal protein content of diets is still quite inadequate. Notwithstanding their great nutritional needs, these developing countries may have to give even further emphasis to fishing for raw material for reduction operations in the more immediate future, in order to earn, through export, foreign exchange necessary for the expansion of industry (including fisheries operations serving the domestic market for food fish). The possibility cannot be entirely discounted, however, that development of low-cost protein products from mineral resources, and rising costs in fish reduction, might eventually put a brake on continued expansion of markets for feed components of fishery origin.

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3. For the above reasons, efforts to develop products for direct human consumption from what are at present considered "marginal" resources used for reduction purposes, should not be neglected. In this connexion it is necessary to point out that, for some time to come, private enterprise will not find it attractive to supply inexpensive products to the malnourished poor of the developing regions. If fish is to fulfil its potential role in the fight against hunger, public policy will have to be oriented toward giving developing countries an opportunity to participate in increasing measure in the harvesting and domestic utilization of fishery resources. The products required for this market may very well be, in the more immediate future, primarily cured products produced by simple means from the cheaper varieties of fish. On their own, developing countries will not be able to solve the problems. Developed and centrally planned countries and international aid agencies will have to lend capital and skills for the launching of large-scale fishing and fish processing operations and help in developing markets, educating consumers, etc. Moreover, before many developing countries will be able to meet fish protein requirements from their own production, the rest of the world may have to provide food aid in the form of fishery products (or make available imports at special bargain prices) to prevent famines or mitigate nutritional crises.

4. In developed countries, particularly in North America and Western Europe, demand is concentrated on certain species of fish rather than on fish as a whole. The trend is toward luxury-type, more elaborately processed products with "convenience" characteristics (e.g., "ready-to-serve" products). Lower-unit-value products often are in strong competition with other animal protein products such as poultry, red meat, and egg products. In centrally planned countries, fish protein has been considered cheaper to produce than land-produced animal protein. Fisheries policies are likely to continue to aim, as they have in recent years, at increased production of staple-type frozen and cured fish.

5. Data on the production of fishery commodities show that the trend over the past decade has been steeply upward for products of the reduction industry (in particular, meals from oily fish and fish body oils). Trends in commodities for human consumption have been as follows: fresh and cured products have declined in relative importance in the market, canning has maintained its place, while production of frozen products has significantly expanded. Different methods of

treatment involve different cost patterns. Some freezing, canning, and fish meal production operations require heavy commitments in servicing capital. These commitments can only be entered into economically where the catch is sufficiently large, cheap and regular, and where it consists of a few main species or groups which are technically suitable for the process in question, and for which there is a large enough home or foreign market in which to recoup the overheads.

6. The character of fish production, too, has changed with increasing industrialization of catching operations in high-seas fisheries. Technology has become complicated and production units have increased in size. Processing at sea has grown considerably with the extension of the radius of fishing operations and thanks also to technological developments and to the organization of integrated fleet operations. So far, however, only very large enterprises - such as those organized, for example, by Japan and countries with centralized economic planning - have been able to cope with the financial and crewing problems encountered in running vertically integrated high-seas fisheries operations.

7. Different species vary in regard to suitability for different types of processing, on the basis of availability, cheapness, and regularity of supplies as well as physical size and chemical composition (e.g. water and fat content). Preservation, handling, and distribution difficulties impose severe limitations on the use of "fresh" fish in tropical climates. Canning for domestic use is likely to occupy only a relatively minor place in the industry of most developing countries until lower-unit-value species like sardinella and related fish and the cheaper varieties of tuna-like fish can be economically exploited and marketed. Since cured fish appear to offer the best immediate possibility of increasing supplies, especially in areas at a greater distance from the coast or from the shores of lakes and rivers, development efforts are likely to pay continuing - and in some instances, even increasing - emphasis on the improvement of traditional methods of fish preservation. Before markets have been developed for inexpensive fish protein concentrates and inland distribution of frozen fish has substantially expanded, the urgent needs for additional animal protein of developing countries are likely to be met most economically from increased supplies of cured products produced in the traditional sector.

8. Considerable improvements are possible in the application of chilling to preserve freshness during distribution and the development of the fisheries of

developing countries is likely to lead to a great increase in the demand for ice. Although new methods of preservation, such as radiation sterilization, or super-dehydration, combining perfect reconstitutability with good storage properties, may some day alter the situation to some degree, the extended application of existing methods of freezing and canning for long-term preservation are likely to be more important in the more immediate future, from the standpoint of the requirements of developing countries.

9. About a third of the world catch is exported. Whereas in the case of the "food catch" the proportion is about a fifth, in the case of meal and oil it is roughly two thirds. World trade is influenced by the circumstance that the effective demand for fish and fishery products comes to a large extent from a comparatively small number of high-income countries. Although many countries export or import fish, the bulk of the trade is between relatively few of them. The volume of world trade in fish and fish products has shown a great expansion in recent years, by far the largest factor in the growth being increased shipments of fish meal, originating in Peru. As far as fish for food is concerned, most of the major exporters and importers are developed countries, many of them with advanced fishing industries.

10. FAO and other international, as well as regional, bodies concerned with fisheries matters are assisting Governments in promoting the development of fisheries industries and in making available increased supplies of fish protein for domestic consumption and export. The tasks undertaken in this connexion include the following: dissemination of research findings of modern science and technology; creation of a favourable climate for industrial development; removal of institutional barriers to production on an industrial scale; establishment of improved facilities for production, processing and distribution; initiation of training programmes for operatives in all sectors of the industry and promotion of consumer education programmes. FAO field experts assigned to developing countries are providing technical services required for planning of industrial development projects relating to the construction and operation of processing establishments, cold stores, ice plants, water and fuel facilities, etc. Elsewhere, assistance is given in the establishment of quality control measures; the improvement of the level of technical efficiency of plant workers, the development of suitable products from available raw materials; the promotion of better packing and distribution methods, etc. Other projects promoted with FAO assistance have included the establishment of pilot demonstration plants for the salting, drying and smoke-drying of fish; the

planning of fish terminals, facilities for cold storage, ice plants, smoke houses, storages and laboratory facilities; the provision of advisory services to fishery enterprises; the organization of cost accounting in processing plants, and the analysis of domestic and export markets for fishery products. Closely related to the projects concerning the secondary and tertiary sectors of the industry is the work carried out by FAO in the primary sector, and in connexion with industries providing the requisites for fish production and processing. Most field projects include work on resource surveys, assessment, or cultivation and on the construction, introduction, and the training in the employment, of new (and improvement of traditional) fishing craft and gear.

11. A comparatively recent development is the assistance given to industry under the FAO/IBRD Co-operative Programme. The aim is to identify projects for international financing in the area of fishing harbour construction, fleet expansion, and other aspects of industrialization. Since the International Bank is able to provide necessary finances for major development in instances where private capital may be reluctant to assume the risks, this Programme is of great potential significance for the long-run future of fisheries industries in developing countries.

I. DEFINITION AND CLASSIFICATION OF FISHERY RESOURCES

12. Fishery resources are defined as the sum total of animal and plant life inhabiting approximately three fourths of the surface area of the world occupied by ocean and inland water bodies and which are exploited (or are potentially exploitable) by man for food or for non-food industrial purposes.

13. The basic classification of production in the primary sector of the industry is by species and groups of species. The FAO Yearbook of Fisheries Statistics groups fishery resources as follows: (1) freshwater and diadromous fishes; (2) marine fishes; (3) crustaceans, molluscs, and other invertebrates; (4) whales; (5) seals and miscellaneous aquatic mammals; (6) miscellaneous aquatic animals (e.g. turtles, frogs) and residues (pearls, shells, sponges, corals, etc.); (7) aquatic plants.

14. With the exception of "residues", all groups can be utilized as food for man. Human consumption is the principal use for fish and shellfish (groups (1), (2), and (3) above). For the other groups, industrial uses are more important.

15. A constantly growing share of the fish used for food is handled and processed in some manner. The operations range from the beheading, eviscerating and filleting of fresh fish to what are sometimes quite elaborate industrial methods for making available to the consumer well-flavoured, ready-to-serve dishes.

16. Non-food uses are numerous and diversified. A large part of the marine fish and whale catches are reduced to meal and oil. Meal plays an important role in pig and poultry feeding; oil is used in the manufacture of margarine and shortening as well as for a variety of other industrial purposes. Skins of some species of fish (e.g. sharks) and hides of some aquatic mammals (hair seals and walruses) are made into leather and, in the case of seals, also into valuable furs. Skins and wastes of other species are used in the manufacture of glue; the swim bladders of certain fish in the manufacture of isinglass, a form of gelatine used in food preparations and in the fining of beers and wines; the ambergris derived from the intestines of sperm-whales in the manufacture of perfume. "Pearl" essence, used in the manufacture of artificial pearls and certain paints, is made from the scales of herring and related fish. Other uses for fish scales are in the manufacture of a foam-producing compound (for fire extinguishers) and of activated carbon. In relation to their weight, no aquatic products are more valuable than those of the pearl and pearl shell industries. Other valuable ornamental materials are produced by the coral and tortoise-shell industries. The natural sponge industry has survived

locally, notably in some Mediterranean countries and in the Caribbean area, in spite of strong competition from artificial substitutes.

17. Aquatic vegetable products include seaweeds used primarily for human consumption or in the manufacture of glues and of media for bacterial growth such as agar (the latter has a variety of additional uses in food and medical products). New uses in food and other industries have been and are being developed and production of seaweeds is growing in some countries.

18. To assess opportunities for industrial development more must be known, as a rule, than the species composition of the fisheries' take. Information on the potential of a resource and on the relation between effort and catch are necessary, among other reasons, to determine whether it pays to exploit it commercially. Breakdowns by fishing areas, season of the year, size classes of individuals taken, production units and gear and fishing methods employed in capture, and landing district, provide clues on the type and size of facilities required for efficient utilization and processing.

II. PRIMARY PRODUCTION

19. The fisherman is not normally in a position to make an accurate assessment of his "stock". Abundance can in most cases only be determined indirectly, from the size of the catch. The addition of boats to the fishing fleet will lead to a decrease in the catch per boat; at high fishing intensities a decrease in the total landings (over-fishing) may result. Because of the "common property" character of most fisheries, there is usually no barrier to entry and the fishing effort, therefore, tends to expand to a level beyond the optimum economic or physical yield. Sometimes the fishing reaches an intensity where even the biological existence of individual, commercially very valuable, species (e.g., the blue whale) is threatened.

20. The element of chance which characterizes all "hunting-type" fisheries operations complicates planning for industrial development. The unpredictability of catch results hampers the determination of the economic size of production units, in fishing as well as in shore handling and processing operations. This notwithstanding, most large-scale industrial development is based on resources taken in offshore sea fisheries operations rather than on cultivates fresh-water or inshore resources controlled by individual or group ownership rights.

21. The world fisheries catch has expanded by over four fifths in the last decade, from 28.9 million m. tons in 1955 to 52.4 million m. tons in 1965. Marine fishes represent a large majority of the species taken; their proportion of total catches has increased from somewhat below - to somewhat above - three fourths. In 1965, the remainder of the world catch was accounted for by freshwater and diadromous fishes with 13.7 per cent, crustaceans, molluscs and invertebrates with 7.8 per cent, and other species (divisions 4 to 7 in the FAO classification) with 1.4 per cent.

22. Herrings, sardines, anchovies and related fishes have traditionally figured most prominently in fisheries catches. In recent years, because of the growth of reduction industries in some countries (notably in Peru and Chile), production of these species has tripled to a volume of almost 18 million m. tons. In 1965, over one third of the world catch was made up of fishes in this group. Ranking next in the marine fish catch total are the following groups: cod, hake, haddock and related species (over 6 million m. tons); red fish, bass, etc.; mackerel,

billfish, etc.; tuna, bonito, etc.; flounder, halibut, sole, etc.; and shark, ray, chimaera (none of the latter groups contributing more than 3 million m. tons). All of the above-mentioned groups of species are raw material for important processing industries.

23. Of the freshwater and diadromous fishes only the group of salmon, trout, smelt, etc., the world production of which is below 1 million m. tons, has so far been of major significance in the establishment of processing operations. The bulk of freshwater fish catches are still used relatively close to landing places, making it possible to dispense with more elaborate provisions for preservation. Crustaceans such as shrimp, lobster, etc., make up little more than one fourth of the total catch (1.2 million m. tons in the crustacean, mollusc and other invertebrate group, with molluscs accounting for most of the remainder). Because of their high unit value, and because of the prominent place in the fisheries trade (especially in developing countries), catch figures do not adequately reflect the importance of crustaceans in the fisheries economy. The same can be said of some quantitatively insignificant items included in miscellaneous animal and plant species and residues. The value of the production of the world's pearl and pearl shell industries, for instance, has been estimated to exceed $US100 million.

24. Estimates of the value of fisheries catches are harder to come by than of quantities taken. Aside from incomplete reporting of value data and the difficulty of bringing different national currencies under a common denominator, the lack of value information on the catches of countries with centrally planned economies makes it possible to arrive at only a very approximate indication of the total value of the world fisheries catch. On the assumption that countries for which value data are not available would value their catches on the same basis as countries with a similar species composition, world production at the primary producer's level may be estimated to be worth from $US7,000-$US8,000 million.

25. Value added from the time of landing to ultimate disposal is even more difficult to estimate, because of the large variety of industrial uses. For a complete assessment of the economic importance of fisheries, the income generated by the various input industries would also have to be estimated. Even in the absence of relevant statistical data it is evident, however, that fisheries occupy a much more prominent place in the world economy than would be indicated by measuring catch value in relation to the value of total gross product.

25. The Pacific Ocean is the source of nearly one half of the total world fisheries catch, with the greatest concentration of fishing in the western-central and south-eastern parts. The Atlantic Ocean contributes about 38 per cent, the fishing being heaviest in the north-eastern part. Compared with the Pacific and Atlantic Oceans, the fisheries of the Indian Ocean are of modest size, their share of world catches being less than 4 per cent.

27. Inland fish production is largest in Asia, where two thirds of all freshwater and diadromous fish are taken. Africa and the USSR rank next, each accounting for close to 10 per cent of the world production of inland fish.

28. Asia is the leading producing continent. While somewhat lower than a few years ago, its share of the world fisheries catch is still close to two fifths. Another 30 per cent of the world catch is landed by European (including USSR) fishermen. Ranking after Asia and Europe are South America, North America, Africa and Oceania, respectively with 17.2, 8.5, 5.8 and 0.3 per cent of the 1965 world catch.

29. Most pronounced has been the increase in South American catches, which, as little as ten years ago, were still only of minor significance in world fisheries. Peru has made the biggest strides as a result of the expansion of fishing for reduction purposes. In the USSR and in Mainland China, too, production trends have been steeply upward.

30. Measured by the advance in fisheries development of Peru and Mainland China, the progress made by other developing countries has been considerably smaller. Nearly all developing countries of Asia, i.e., India, the Philippines, Thailand, the Republic of Korea, Taiwan, Pakistan and the Republic of Viet-Nam, however, show a rising catch trend, chiefly of food fish (for domestic consumption or intra-regional trade) but also of higher-value crustaceans and tuna exported to North America, Europe and Japan. Developing countries in other regions which have succeeded in expanding their fisheries production are the Central and South American shrimp-exporting countries and, on a relatively smaller scale, some countries on the African continent.

31. At least a dozen countries have fisheries catches exceeding 1 million m. tons. Peru's production in 1965 was in the neighbourhood of 7.5 million m. tons and the year before had reached a record total of 9.1 million m. tons. Japan and Mainland China also have fisheries crops above 5 million m. tons, and the USSR's production

is rapidly approaching this level. Following these countries are the United States, Norway, South and South West Africa, Spain, India, Canada, Iceland and the United Kingdom.

III. UTILIZATION OF FISHERY RESOURCES

32. Utilization patterns may be discussed from two viewpoints: (a) type of transformation operations to which the resources are subjected, and (b) market characteristics of the products produced. According to the first classification criterion, a basic distinction is made between distribution as fresh fish and utilization for freezing, curing, canning, reduction, and miscellaneous other processing operations. While some fresh fish is retailed directly at the port, it is today more often "processed" in some form (beheaded, eviscerated, filleted, etc.) before sale to the consumer, especially in developed countries. In contrast, fish classed as "processed" fish often includes, especially in developing countries, products like sun-dried fish prepared in the most rudimentary fashion, without use of expensive capital equipment. Statistical totals for some processed products, as a result, are likely to include commodities manufactured with elaborate and expensive equipment and methods as well as commodities produced by the most primitive means (dried fish production totals provide no indication on the proportions produced by simple sun-drying and artificial dehydration respectively).

33. A substantial portion of the fishery catch is processed in more than one way before reaching the consumer. This, too, tends to detract from the usefulness of a classification by type of transformation method. In some countries, thus, cured and canned fishery products are manufactured increasingly (partly as a result of the growth of freezing at sea operations) from frozen rather than from fresh fish. In many instances, freezing operations are carried on today to ensure stability and regularity of raw material in the manufacture of more elaborately processed products to supply the frozen food market and to distribute thawed frozen fish as "fresh fish".

34. When considered from the standpoint of final product use and market acceptance, the following utilization patterns can be distinguished: in general, reduction and miscellaneous other industries manufacture products not destined for direct human consumption; freezing, canning, salting and other forms of curing operations, in contrast, are carried out to preserve fishery resources for the food market. Still, while the fish meal and fish oil produced by the reduction industry is at present used virtually exclusively in animal feeding, experiments are under way to manufacture and distribute a fish protein concentrate which meets the nutritional and economic requirements imposed by the market for human food. Nor is all of the production of

the food processing industries disposed of for human consumption, sizable segments of the fish canning industry, for instance, serve the pet food market.

35. The distinction between products for human consumption and products destined for industrial uses is important, since the demand for the intermediate products in the latter category is dependent on conditions in end-product markets. For products sold for direct consumption, it is useful to make a further distinction between "staple" and "luxury" type products, because of substantial differences in the character of the demand. Here again, classification by type of transformation operation is not sufficiently revealing: while in higher-income countries some canned fish products are classed as "inferior" products, the consumption of which tends to decline with rising incomes, sales of other canned fish products, e.g., of preferred varieties of canned tuna and canned salmon, increase quite significantly when improved living standards enable additional consumers to become more discriminate in their food purchases.

36. A basic factor determining utilization, and needs for processing, of fishery resources is the size of the catch measured against the market absorption capacity for fresh fish. The smaller the latter in relation to supplies, and the greater the distance of markets from landing points, the more extensive are the provisions that must be made for the preservation of the fish. Other factors influencing utilization are seasonal fluctuations in consumption, changes in consumer habits and preferences, and changes in consumer purchasing power.

37. Seasonal and secular patterns are also recognizable on the supply side. They are related both to the behaviour of the individual species and to factors governing fishery exploitation (the radius of fishing operations, management controls, etc.).

38. In some areas, processing operations have not expanded as fast as might have seemed warranted by the rate of catch increase. Extensive development of refrigerated ship, ice plant and cold storage, and land transport facilities may have made it possible to handle larger quantities of fresh fish. Elsewhere, especially in developing countries, lack of investment capital for processing has been, and continues to be, a major factor holding back development of manufacturing facilities. In most developing countries, low purchasing power and relatively fixed food preferences of consumers are other factors which have prevented the expansion of markets for fishery products manufactured on a more ambitious industrial scale.

39. The above notwithstanding, the need for products with a longer shelf-life as well as technological advances have led to a considerable growth of fish-processing operations on a world basis in recent years. The long-term trend indicates that manufacturing will expand more rapidly than fresh fish marketing.

40. Some fish species lend themselves more easily for processing in one form rather than in another. In general, lean fish are less suitable for canning than fat fish. Fish low in fat content, on the other hand, are more suitable for drying operations, since reduction of the water content does not prevent oxidization of the fat.

41. Aside from fat and water content, size - which differs from species to species and for different age groups of a single species - also is a factor in determining suitability for certain processing operations. Small fish and shellfish, thus often cannot be economically filleted, deveined, etc., and are, as a rule, preserved by simple methods not requiring expensive capital equipment.

42. Table 1 gives particulars for the disposition of world fisheries catches in 1955 and 1965. In absolute terms, utilization in all forms[1/] has significantly increased. Only reduction and freezing operations, however, have made a relative gain, the increase in utilization being especially pronounced in the case of reduction. Canning operations took almost the same share in 1965 as in 1955, whereas the fresh fish and cured fish shares have declined.

Table 1

Disposition of world catch[2/]

	1955		1965	
	Live weight (millions m.t.)	% of total	Live weight (millions m.t.)	% of total
Total Catch	28.9	100.0	52.4	100.0
Utilization:				
Marketed fresh	12.4	42.9	17.5	33.4
Freezing	2.0	6.9	5.7	10.9
Curing	7.2	24.9	8.1	15.5
Canning	2.7	9.4	4.8	9.1
Reduction	3.6	12.4	15.3	29.2
Miscellaneous purposes	1.0	3.5	1.0	1.9

1/ The trend for the "miscellaneous purposes" category cannot be assessed.

2/ FAO Yearbook of Fishery Statistics, Vol. 21 - 1965.

43. If one assumes, for convenience purposes, that supplies used for fresh marketing, freezing, curing and canning are destined for human consumption, and supplies for reduction and miscellaneous purposes for industrial uses, the data show that, in 1965, 68.9 per cent of the world's fishery production was used directly for food purposes as against 84.1 per cent in 1955. The comparison should not be interpreted necessarily as a reliable clue on future trends; it illustrates the startling growth of the reduction industries of Peru and Chile during this period, possibly a unique occurrence in fisheries development.

44. Geographically, utilization patterns are as follows: for fresh fish marketing, a cool climate, short distances to large markets and good infra-structure facilities for the distribution of highly perishable foods are essential. Fresh fish has maintained its market position in developed countries where these conditions obtain, e.g., in the United Kingdom and in Scandinavia. Fresh fish consumption is considerable, however, also in some tropical developing countries where fish not eaten on the day of capture must be preserved in some fashion. These countries usually have either many small inshore marine fisheries extending along their coastlines or inland water fisheries not too distant from market centres, making possible disposal of a sizable share of catches as fresh fish.

45. Frozen fish distribution has expanded most rapidly in countries where, at the time new fish freezing facilities were created, a cold chain was already in existence to handle the output of the industry. The United States, Japan, the USSR, and the countries of Western Europe lead in the consumption of frozen products, obtaining supplies from their own industries as well as from producers in the north such as the Scandinavian countries and Canada.

46. The high-income countries also are the principal markets for canned fishery products. The United States is the chief consumer of canned tuna and canned salmon. Canned herring and sardines are consumed more widely throughout North America and Europe. While still limited on an over-all basis in the developing areas, consumption of cheaper varieties of canned fish is relatively high in some countries, e.g., in the Philippines. Morocco and Peru are two developing countries which produce sufficient quantities of canned fish to have a surplus for export.

47. Cured fish production and consumption is on the decrease in most developed countries but remains important in developing countries. The simpler methods of salting, drying, smoking, pickling and fermenting are less costly than other

processes and the products, therefore, best suited for low-income markets. Climate and the availability of preservative materials influence the type of cure used. Existing consumption patterns sometimes impede the introduction of new cures.

48. Fish processing operations range from primitive, subsistence-type, sun-drying, requiring virtually no capital investment, to modern large-scale freezing, canning, and fish meal industries. In developed countries, small-scale local processing survives only in isolated coastal areas, where a large part of the population depends on fishing, and where communications to major market areas are inadequate. Area development programmes seek to replace such operations with up-to-date industries, which are able to compete with food processing industries manufacturing products the consumer tends to substitute for fish (red meat and poultry products).

IV. THE FISH FREEZING INDUSTRY

49. The rapid expansion of the frozen fish industry in recent years has been influenced by both supply and market factors. On the market side, the general trend in demand toward prepackaged frozen food, and the wider diffusion of frozen food storage facilities in wholesale and retail establishments and in the home, have increased the distribution potential. At the same time, extension of the radius of fishing operations, with larger craft making longer trips, has made it necessary to seek ways of preserving catches on board by better methods than simple packing in ice; in many instances, this has been accomplished by freezing fish at sea. Much of the sea-frozen fish is sold in frozen form, although some of the frozen landings, especially in some fisheries and in some countries, is canned (e.g. tuna in the United States) or cured in some form. In some cases, sea-frozen fish is sold as "fresh fish" after thawing on land.

50. Processing at sea rarely extends to the preparation of consumer packages. The fish which is bulk-frozen at sea for eventual processing in shore plants into canned, salted, and other products is thawed on landing before it is further processed. Even most of the bulk-frozen fish that is eventually retailed in frozen form is thawed, filleted on shore, refrozen and packaged, either in larger institutional - or smaller consumer-size - packs.

51. A fish freezing plant, which is merely one link in the unbroken (from landing to consumer household) cold chain required for the distribution of frozen fish, has equipment which varies from the simple and crude to the large and complex. Most plants are on or near the water - often located on piers so as to be readily accessible by boats. Large food processing companies, however, may freeze fish in conjunction with other foods and the plants in these instances - especially where fisheries do not account for a major part of the business - may be located inland.

52. Most fish freezing plants make ice, some do a public warehousing business - not necessarily for fish only. Some plants freeze and store fish for customers at a fixed charge, whereas other plants own their holdings outright, and buy and sell fish so as to take advantage of seasonality in fishing and market conditions. Facilities and practices in freezing and cold storing of fish are not standardized. Differences exist with respect to geography, species utilized, and market requirements.

53. The choice of freezing equipment and method is influenced by the species of fish to be frozen and by market considerations. A large number of techniques and apparatus for freezing fish have been developed in different countries; the three methods used on an industrial scale today are: brine freezing; air-blast freezing; contact freezing.

54. In brine freezing, both by immersion and spraying, the fish comes into direct contact with the cooling medium. In most countries, sodium chloride is the only brine-forming solution which may be used in freezing.

55. The lower the brine temperature and the shorter the immersion time, the smaller is the amount of salt which penetrates into the fish. Only whole fish is suitable for freezing in brine since skin has sufficient resistance against salt penetration. The freezing temperature in brine freezing must not be below -21.1°C. To prevent contamination of the fish and adverse effects on the flesh, it is essential to filter the brine and to renew it from time to time.

56. Air-blast freezing is used very widely, because it permits the processing of fish of different shape and size. Investment in facilities is lower than for the other methods; on the other hand, air-blast freezing requires more electrical power per weight unit of frozen product. Freezing takes place in a blast of air which circulates around the product. Freezing temperatures, as a rule, are not lower than -35° to -45°C, since lower freezing temperatures are as yet uneconomic.

57. As far as the possibilities of freezing fish of different shapes are concerned, contact freezing offers almost the same flexibility as air-blast freezing. Contact freezing has become widely applied in recent years, particularly for the freezing of fish products in consumer packs and in the freezing of fish at sea. Various types of freezing apparatus are employed. While the horizontal multi-plate freezer is only suitable for freezing fillets, steaks and small fish in rectangular packs, the vertical place freezer can be used for freezing whole and round fish of various shapes and sizes (except very large fish), and is also suitable for freezing fillets in blocks, especially if the frozen product is to be used for further processing, e.g., as fish sticks.

58. The shelf freezer is a modification of the air-blast freezer. Here the fish is put on cooled shelves and is frozen in a stream of air. This combination of air-blast freezing and contact freezing results in the reduction of the freezing time.

59. Special problems occur in freezing fish at sea on smaller trawlers where space is limited, where the crew has only a limited amount of technical knowledge, and where repair and maintenance facilities are inadequate.

60. The freezing rate within a certain range has little influence on quality but the freezing of fish at too slow a rate by simply placing it in a cold store or by partial freezing will result in deterioration of quality.

61. Frozen fishery products are thawed in water, in air or by cooking or frying in the frozen state. Dielectric heating, which reduces the time required for defrosting, is used to some extent in thawing freezer trawler fish as well as in thawing of prepared fish meals and consumer packs.

62. During cold storage the quality of frozen fish is affected by oxidation and desiccation. This factor is thought to be one of the major reasons for holding back development of fish freezing.

63. The frozen fishery products should be stored in the cold store in such a way that sufficient air circulation is ensured. Relative humidity should be as high as possible in order to avoid freezer burn and loss of weight. The most important factor in preventing quality deterioration is the maintenance of constant low storage temperatures which should be at or near -30°C for all high-quality fishery products and, as necessary, for the storage of fatty fish. Glazing, wrapping in moisture-proof packaging material, and freezing in alginate solution or in water, also help to prevent fat oxidation and desiccation of the products during cold storage.

64. Freezing is at present the only method which can preserve the fresh fish characteristics during long storage. In addition, it offers, if applied on a large scale, the following advantages common to industrialized processing: consistent quality; products variety; possibility to stabilize supply and price; hygienic packaging and distribution; standardization of product type; extension of range of retail outlets; creation of an incentive for manufacturers to use modern advertising.

65. The above factors account for the growing interest, in developing countries, in the establishment of fish freezing plants and frozen storage facilities. On the other hand, the initial capital investment is high, and the costs of storage and distribution are substantial. The economic feasibility of the marketing of frozen fish, therefore, is directly related to the capacity and geographical range of cold

storage and transport facilities, both at the wholesale and retail stages, and, to some extent also, to the amount of refrigerated storage space in consumer homes and in institutions. In the absence of a cold chain, the economic implication of establishing a chain based on frozen fish distribution alone must be carefully assessed. Usually, costs are too high; opportunities for frozen fish distribution are, therefore, to a large extent determined by the stage of development of the frozen food industry in general.

66. Costs of freezing and cold storage facilities and operations can, to some degree, be reduced at the expense of quality. Quality requirements are determined in terms of what is accepted by the market (and what is considered safe from a health standpoint by the authorities) rather than in terms of any universally applicable standards. There is an economic limit, however, beyond which the savings achieved, e.g. by using freezing or storage temperatures higher than those necessary for the production of products of good quality, will not "pay". This point is reached when financial losses attributable to spoiled products, which have to be discarded, or to lower receipts for inferior-quality merchandise will exceed the savings realized by the lowering of technical standards.

V. THE CANNING OF FISHERY PRODUCTS

67. While not increasing as rapidly as freezing, the preservation of fish by canning is steadily expanding, amongst others for the following reasons: availability of larger and more regular raw material supplies, by virtue of extension of the radius of fishery operations and the use of refrigeration on board vessels; development of canning operations at new locations; increased mechanization of handling and processing operations; greater variety of packs and, as a consequence, better acceptance of canned products in the market.

68. For the marketing of canned fishery products, no special facilities are required. The keeping qualities of adequately sterilized products are almost unlimited and the products can, therefore, be distributed at low cost to consumers through an existing transport and storage network. Canning also offers wide scope in adapting products to specific consumer preferences in respect of texture, taste and flavour.

69. Development of fish canning operations is frequently held back by the high cost of tin plate required for the containers. In low-income countries, the high cost of the container may more than cancel the cost advantages on the storage, transport and marketing side, and may make canning operations less attractive to the entrepreneur than other fish processing operations.

70. A relatively small number of species, generally the more oily fish, are used for canning. Basically, the canning process seeks to prevent spoilage by inactivating micro-organisms through heat. Certain additives may be used in processing to enhance taste or preservation (additives of the latter type are permitted only in a few countries).

71. In canning operations, the raw material is packed in airtight containers before heat sterilization. Processing techniques differ little from product to product. The actual canning operation involves the pretreatment of the fish as well as the preparation of the can, the filling, vacuumizing, and closure of the can, the heating of the filled cans to a degree that adequate inactivation of micro-organisms is attained without too much damage to the fish, and the cooling, cleaning and storage of the product. Related problems are the preservation of the fish prior to canning, control of the manufacturing operation, and inspection of the canned product.

72. Canning facilities should preferably be located at points where fishing and processing operations can be carried out simultaneously. If the plant is established on the waterfront, the raw material can be hauled directly from the vessel to the plant which may make for better quality of raw material and also lead to economics in operations. For the same reasons, handling within the plant should be restricted to an absolute minimum and be mechanized as far as possible and the flow of material should be direct from receiving point to warehouse without criss crossing. In general, plant layout and organization of the flow of operations have a significant impact on the economics of the canning operation. Investment costs for a canning plant, including costs of site, buildings, canning equipment, facilities for the provision of heat, power and water supplies, for the receiving and storage of raw material and internal transportation, etc., are on the high side.

73. Deterioration of raw material quality can be prevented, to some extent, by arrangements for temporary bulk preservation which may take the form of chilling or, if the interval between catching and canning exceeds several days, bulk freezing.

74. Treatment of raw material before canning includes, among other operations, dressing, salting (primarily to enhance taste), and often precooking (which may be by boiling, steaming, drying, smoking, etc.) to decrease water content before placing the raw material into the can.

75. Dressing operations for smaller-size fish usually include scaling and removal of head and intestines; for larger-size fish cutting up in portions, and, for tuna, also the removal of the backbone, and the sorting-out of various parts of the meat for different packs.

76. In the choice of can for packing, the fact that seafoods are sulphur-staining must not be overlooked. Sulphur-resistant coated cans, therefore, have to be used. During storage, the empty cans must be protected against damage and corrosion. They have to be carefully stored for this purpose in a dry closed room. Before filling, they are often washed to remove dust and micro-organisms.

77. The canning operation itself involves the following steps: filling of the fish into cans; addition of substances to enhance flavour or otherwise improve quality; exhausting, i.e., vacuumizing, to remove air from cans; closing and sealing of cans; heating - also referred to as "retorting"; cooling and washing the processed cans; labelling, packing and storage; use or disposal of cannery waste.

78. In larger-size canning plants, adequate measures must be taken to ensure economic disposal of the cannery wastes. Reduction operations may be justified if sufficient quantities of offal are available.

79. As in other fish-processing operations, complexity of facilities and methods in seafood canning may vary considerably, depending on market requirements and on the resources available for the development of the industry. More elaborate arrangements thus are necessary for packs which are sold in quality-conscious markets of developed countries. High labour costs in the same countries may favour mechanization of operation. If the pack is seasonal, however, mechanization cannot be carried very far, since expensive machinery would have to lie idle for extended periods of time. In developing countries, too, canning operations will tend to be labour-intensive.

80. There is some concern over the future of the trade in canned fishery products of the "staple" variety. Markets may decline because, in developed countries, the demand for these products is characterized by lower income-elasticity than that for high-grade fresh and frozen fishery products. At the same time, in developing countries most canned products will continue to be too expensive for the average consumer preventing expansion of the market on a scale that might fully compensate for a net decline in sales in developed countries. Canned fish is likely to enjoy a growing demand, however, in those developing countries where the very exacting transport of cooled and frozen foods is not yet available but where the public taste is changing, as it already has in many developed countries, from a preference for dried, smoked and salted fish to more mildly flavoured products.

81. A few basic conditions should be met if canning is to be introduced. These are: fish species suitable for canning should be available in sufficient quantity and of adequate quality at regular intervals, and reasonable prices; products acceptable to the consumer must have been developed so that no difficulties are encountered in finding market outlets for the pack, there must be access to adequate communications and energy and water sources; a relatively large supply of unskilled labour that can be rapidly trained to perform the bulk of the canning operations not requiring special skills, and a relatively small number of highly skilled personnel for supervisory and technologically specialized jobs, should be available.

VI. THE CURING OF FISHERY PRODUCTS

82. The concept "curing" comprises a variety of processing techniques aiming at the preservation of raw material by dehydration and addition of chemical substances, or both. Additives and chemical changes effected during curing often impart a desired flavour to the product.

Drying

83. Drying, either alone or in combination with salting or smoking - or in combination with both - still accounts for the largest share of the fish.catch used for processing for human consumption.

84. Drying does not succeed as well as freezing in preserving the characteristics of fresh fish. This, to a large extent, explains the relative growth in importance of freezing, and the relative decline of drying operations. Low cost of preparation, transport and storage, however, assure dried products of the staple variety an important place in the markets of many developing countries for a long time to come. Dried products are easily infested by insects if not properly processed and stored.

85. With the exception of drying racks and storage facilities, no capital equipment is needed for the production of dried fish by natural air drying. Dehydration (artificial drying) differs from natural drying in so far as it is a process which aims to reduce water content under carefully controlled conditions, generally by mechanical means, so that the effect on appearance, odor, flavour, texture and nutritive value following reconstitution is minimized. Therefore, the costs of preparation, and often also of packaging and storage, of dehydrated products are usually higher than those of naturally dried products. For dehydration, arrangements are necessary to control the temperature and air currents generated to effect drying. Facilities employed include wind tunnels, fans and heaters, and trucks moving on rails on which the raw material is passed forth and back during drying operations. Of the new dehydration techniques which have been experimentally tried out by the food processing industries in recent years, accelerated freeze-drying holds out promise for certain products, since it comes closest to producing a product which, when reconstituted, resembles fresh fish in taste and texture.

86. The advantages of dehydrated over naturally dried products include a considerable time-saving in processing operations, quicker reconstitution before consumption, and better texture and flavour.

87. In natural drying, the raw material cost accounts for all but a modest fraction of the total cost of the dried product, especially where the fisherman's family provides the labour. Species used and yield of product are the two principal factors affecting raw material costs.

88. When natural air drying is handicapped by unfavourable climatic conditions, dehydration makes for greater efficiency of operations. In some developing countries, however, the more elaborate forms of dehydration have not been introduced so far because of the comparatively high plant, fuel, and packaging costs.

Salting

89. While salt is often used either as a condiment or an auxiliary preservative in other processes of fish preservation, "salting" is the process in which it is the chief preservative. Markets for salted fishery products have been on the decline in developed countries as a result of changes in dietary habits as well as because of increased utilization for freezing of species at one time processed primarily into salted fish.

90. Salt acts as a preservative by extracting water from the raw material. Quick penetration of the salt into the tissues of the fish is desirable to protect quality. Climatic conditions, the quality of the salt used for processing, and the character and size of raw material supplies are among the factcrs influencing the choice of a processing method.

91. In dry salting, fish is packed in solid salt and the brine formed is drained off. The rate of hydration of the flesh and the penetration of salt into the flesh is high. The size of the salt grains plays an important part in dry salting, as it greatly influences the velocity with which the brine is formed. For this reason, a mixture of fine- and coarse-grained salt is usually advisable. Dry salting is commonly used for lean fish such as cod. The weight of dry salted fish is less than that of the raw material used.

92. In brine salting, the fish is placed in a prepared salt solution in which it is left for the entire salting period. A concentrated salt solution is used and the rate of dehydration is slower than in dry salting. If the fish are kept in brine for more than two days, crystalline salt must be added to the brine. When the salt content of the brine is low, the weight of the salted fish is greater than the weight of the "green" fish; if the brine is strong, the weight is about the same. Brine salting is recommended for salting fatty fish, also for lean fish, if storage at low temperature of the dry salted product is not possible.

93. Under one variation of the brine salting method, the fish is mixed with solid salt in a container or basin and the brine formed is not drained off. Salting takes place almost as rapidly as under the dry salting method. There is always, during salting and the storage of the salted product, a certain amount of solid salt present mixed with the fish and in the brine. This method is preferred for salting of fatty fish in a warm climate and also is suitable for salting lean fish which has to be stored in a warm climate.

94. Vats, bins and barrels are the most commonly used facilities for salting, representing the principal capital investment necessary for these operations.

95. The quality of the salt used as a preservative affects product quality in a number of ways fine salt dissolves rapidly and may cause "salt burn" (a slowing-down of the penetration of the salt as a result of too rapid protein coagulation). Coarse salt again may penetrate too slowly to prevent bacterial destruction during the early stages of salting but it keeps the fish better separated. Chemical impurities in the salt may also retard penetration or may cause texture, flavour, and colour changes which may make the salted products less acceptable in the market.

Smoking

96. In smoking operations, preservation is achieved by a combination of drying and deposition of chemicals which are contained in the smoke of burning wood. Cooking fish over an open fire makes it keep longer and adds a distinctive flavour. The quality of the product is affected also by the flavour, which varies with the kind of wood burned and with the other conditions of the process, e.g., the time/temperature relation under which the smoking is carried out. Three methods of smoking fish are distinguished, viz., hot-smoking, cold-smoking and smoke-drying.

97. Hot-smoking is carried out at elevated temperatures. In contrast to cold-smoking, a few hours only are needed for the cooking of the fish flesh. Subsequently, the fish is smoked at temperatures up to about 120°C. The hot-smoked products have an average shelf-life of up to a week in moderate climates, and a considerably shorter one under tropical conditions.

98. In cold-smoking, the temperatures must not exceed 30°C. The method, therefore, cannot be applied in warm climates. The process takes several days, and in some cases several weeks, but the products have a much longer shelf-life (up to a few months) than hot-smoked products if they are stored in relatively dry storage places. The preservative action is mainly due to the high level of dehydration and to the presence of bacterial-killing chemicals in the smoke and, in some products which are rather heavily salted, to a high concentration of salt.

99. Smoke-drying is carried out by exposing the fish to a hot fire to cook the flesh, thus eliminating a big quantity of water in a relatively short time, and by subsequent smoking above a smouldering fire for an extended period of time. It is, in a way, a combination of both the hot- and cold-smoking processes. Shelf-life depends mainly on the water-content of the final product, varying from about 13 to 35 per cent, and ranges from about a week to several months. Storage conditions, with the air humidity playing an important role, also affect shelf-life. One way of extending the shelf-life is by re-smoking, which inhibits the formation of moulds. The products are normally less palatable than hot- or cold-smoked products but, because storage requirements are less exacting, the products are better adapted to marketing in humid, tropical areas. Smoke-dried fish can be salted with varying amounts of salt or prepared even without any addition of salt. The latter is common in many parts of Africa.

100. Salting and brining before smoking seek to improve flavour and keeping quality; the latter depends on the quantity of salt which penetrates into the product. Lean fish, if smoked, keeps longer in good condition than fatty fish. Gutted fish spoils less quickly than ungutted fish but the consumer prefers the latter because it keeps a better appearance after smoking.

101. Traditional smoking operations vary substantially, between different geographic areas and different ethnic groups as well as according to type of fish used, quantity processed, and material available locally for construction and operation of ovens. The most primitive ovens are small wooden or metal grids on which the fish is cooked and smoked in the open air. These ovens are built at virtually no cost by the fishermen and their families; volume of production is merely sufficient to cover home consumption requirements, although where premium inland species constitute the raw material, the fish is often sold. The simplest equipment can handle no more than from 10 to 20 kg. of fresh fish at a time. Larger ovens may have a capacity of up to 300 kg. of fresh fish.

102. In recent years, improved traditional ovens have been introduced, with the help of technical assistance experts assigned under bilateral and international (including FAO) auspices, in tropical Africa, where smoked fish is often preferred over other fishery products by consumers. The main improvements are better quality of product and economies in the use of firewood (per unit of product).

103. The mechanical smoking of fish, under controlled processes, requires equipment to regulate the principal variables in smoking, viz., smoke volume and quality, temperature, humidity, velocity and distribution of air and smoke. This type of smoking has come into use only comparatively recently and requires more expensive installations and highly qualified operators compared with traditional smoking operations. On the other hand, it provides the possibility of producing products of a much more uniform quality, in bigger quantities at a place and at a time and at a substantially lower rate of firewood consumption; it is practically independent from climatic conditions.

104. When labour is plentiful and cheap, as under subsistence-type operations, where the family of the fisherman tends the single oven operated, the watching of the fire and the frequent changing of layers to prevent spoilage are accomplished without difficulty, in contrast to semi-industrial or mechanized operations, where each worker has to take care of several ovens.

Other curing operations

105. **Semi-conserves** or marinades are cured fish products which enjoy considerable popularity in some developed countries, notably in the Scandinavian area, in the Netherlands, and in Germany. They are produced by treating the raw material with **vinegar** and salt and are characterized by typical **odours and flavours (accentuated** by the addition of **spices** and covering liquids). Keeping quality is limited, since - for reasons of taste - it is not possible to increase the amount of **additives** sufficiently to prevent spoilage for extended periods of time. Cold, fried and cooked **marinades** are distinguished; processing procedures vary substantially.

106. **Fermented seafoods** and fish sauces and pastes are regional favourites in **South-East** Asia. While, for the most part, requiring only the most **rudimentary facilities** and equipment for processing, curing procedures are often rather involved and time-consuming. A large part of the production is of subsistence character. Where commercial operations are carried on for the production of individual products such as, for instance, the popular fish sauce, nuoc-mam, large vats with a bamboo tap fitted near the bottom are used in some areas. Methods vary geographically but are all based on the same principle, i.e., the generating of anzymic degradation of fish proteins, in the presence of salt and under anaerobic conditions.

VII. REDUCTION

107. Reduction operations are based on the utilization of fishery resources which can be used more profitably for industrial than for human consumption purposes. Reduction raw material is composed, therefore, primarily of fish which is not eaten by - or has little appeal to - consumers, excess catches which cannot be processed and distributed economically for human consumption, and offal from fish processing other than reduction operations.

108. Industrialization started with the use of catch surpluses for the production of fish oil and fertilizer. Later developments were the use of "fish scrap" and fish meal for animal feed. Today the principal commercial products of the reduction industry are meals, oils and solubles. Of these, fish meal is by far the most important today, as far as both production and trade are concerned. "Edible" fish protein concentrate manufacture and distribution, as already pointed out, has not yet passed beyond the experimental stage.

109. Two methods of fish-reduction are distinguished: the dry-reduction process and the wet-reduction process, the choice of method depending, among other factors, on the oil content of the fish used as raw material. The dry-reduction process involves drying and the milling of the dried fish; it can be used only for the processing of non-fatty species. The wet-reduction process consists of the elimination of oil and water from the fish. This requires relatively complicated processing procedures. The reduction process consists of three basic operations: cooking, pressing and drying.

110. In a typical operation, the fish are unloaded from the vessel holds with the help of a fish pump, deposited at a weighing station, and mechanically conveyed from there into a large storage bin. From the latter, the fish are conveyed to a hopper which feeds a continuous steam cooker of cylindrical form, equipped with screws to regulate the feeding of the fish as well as with thermal controls. The cooking coagulates the protein and breaks the cells so that the oil is easily separated when the fish are pressed.

111. The cooked fish pump enters the continuous screw press which squeezes the freed water and oil from the fish and discharges the thoroughly pressed and matted mass, called "pressed scrap", through a conveyor to a disintegrator. The liquid material, the "press liquor", is caught in a receiving pan located directly under the press.

112. The "pressed scrap" is broken up into small pieces in the distintegrator and then passed into one of several types of dryers where the moisture is reduced to between 6 and 8 per cent.

113. To control the unpleasant odours associated with fish reduction, the gases from the drier may be recirculated and passed through the furnace, where the combustion heat destroys the odours. Alternatively, the gases may be "scrubbed" by passing into a tower containing a number of water sprays. The fine spray absorbs objectionable odours and carried them into a sewer.

114. The fish meal discharged from the drier is ground and then either spread over the floor to cure before it is weighed into bags or packed directly in double-wall paper bags, with an asphalt binder between the walls, to reduce oxidation and deterioration. Sacking the meal, as it leaves the drier, saves labour and makes for a higher quality meal.

115. The fish oil is recovered from the "press liquor" which is composed of water, soluble portions of fish, oil, and suspended proteins. In the manufacture of the oil, solids (usually added back to the meal) are first recovered by means of a filter and a press, and the oil then separated from the water by centrifugal separators or other means. The water fraction is known as "stickwater" or "fish solubles"; it contains minerals, vitamins, amino acids, and other valuable nutritional ingredients. In modern installations, evaporators for stickwater recovery are installed to improve the yield from the reduction process (this can be accomplished either by adding the concentrate liquid back to the press cake or by sale of "condensed fish solubles"), and also to ensure that the easily putrefying waste product does not become a public health hazard when discharged into the sewer.

The recent growth of the fish meal industry

116. The fish meal industry had its origin in the reduction of waste material from other fish processing operations. The fish meal was produced by the most primitive methods and was used mostly for fertilizer.

117. From there, the industry evolved by proceeding to utilize whole fish (of species which either were not accepted by the consumer or which could not be utilized in economic fashion in markets for human consumption). Special methods

and equipment for reduction into meal and oil were introduced eventually and the products were "up-graded" in the market. In the case of fish meal, this led to utilization in the compounding of animal feeds and - more recently, with operations still largely at the experimental stage - development of fish protein concentrates for human consumption.

118. Fish meal operations have expanded in spectacular fashion in recent years. This development has been due, in large part, to the advance of scientific farming and the increased use of fish meal as a component in pig and poultry feeding. Apart from its unique value as a nutritive element in feeding, cost factors contributed to the preference of feed compounders for fish meal over other components. It was fortunate for the industry that, at a crucial time from a market standpoint, large quantities could be produced and delivered to markets at low prices because of the availability of substantial stocks of "industrial-type" fish, like the anchoveta off the Pacific coast of South America, which previously had been "harvested" only by the guano birds.

Fish oil

119. In many countries, and for many years, oil was the principal product of the fish reduction industry. Fish body oils have been used in Europe primarily in margarine and other human food production, whereas in the United States they have a market in the manufacture of various industrial products, including soaps, paints and varnishes, floor covering and oil-cloth, etc. In all uses, there are competing products. Price factors, consequently, are a dominant element in the market.

120. Because of the steeply rising demand for fish meal, fish oil has virtually dropped to the position of a by-product of the reduction industry in some countries, e.g., in Peru. Elsewhere, notably in the United States and in the Scandinavian countries, however, it continues to be of great importance from the standpoint of the over-all economics of reduction operations.

121. In general, processing yields vary with a large number of factors, among them the species of fish used as raw material; for individual species, with season, sexual maturity, temperature and feeding conditions; and with the processing methods used.

122. In Peru, the oil yield, although slowly rising with the introduction of improved processing methods, averages little more than 2 per cent; in the Scandinavian countries and in the United States, which utilize different raw material and which have important overseas markets for their oil production, it has been several times as large.

VIII. PROCESSING OF OTHER THAN FISH AND SHELLFISH PRODUCTS

123. No general observations are possible on the manufacture of the large variety of products which are produced from aquatic resources other than fish and shellfish. The processes range from the craftsman-type carving of cameos from shells to rather elaborate chemical processing techniques used in the production of some food extracts and medicinal preparations.

124. Processing for food or for reduction purposes of marine mammal resources, in particular whale carcasses, does not differ substantially from the processing of fish and shellfish species, except that processing at sea is of even greater importance in whaling than in other fisheries operations. The principal product of the whaling industry is baleen whale oil (although other products - whale meat and sperm oil - are of growing relative importance in the utilization of whale resources). It is used, similarly to fish body oil - after processes seeking to achieve hardening by hydrogenation as well as deodorization - in the manufacture of margarine. By virtue of its different chemical composition (it contains waxes), the oil of sperm whales has different uses; in the United States, for example, it is employed for lubricating precision instruments and commands a premium price in the market.

125. The meat of species other than the sperm whale is utilized primarily for food purposes. Japan has the biggest demand for edible whale products. The basic processes for preserving whale meat are freezing and salting. Frozen or salted whale meat is either consumed directly or further processed into canned products or sausages. Dried or pickled whale speciality products are prepared in some countries, e.g., in the Scandinavian area. The Japanese manufacture edible gelatin from the head blubber and other tissues. Offal from whale processing is reduced to whale meal.

IX. PROCESSING AT SEA AND FACTORY SHIPS

126. Processing of fish and shellfish at sea has greatly expanded in recent years. It is improbable, however, that this trend would ever lead to the abandonment of processing operations on shore.

127. Processing aboard vessels has been encouraged by the extension of the radius of fishing operations. This development, in turn, is attributable to several factors; depletion of stocks in nearby waters, extension of legal fishery limits excluding fleets from traditionally fished grounds, short fishing seasons attributable to natural phenomena (availability of the fish on the grounds for short periods only) or to regulatory provisions, etc. In addition to the above, increased processing at sea reflects also the general growth in the utilization of catches for other than fresh fish marketing.

128. Processing at sea adds another dimension to the three functions normally performed by craft employed in fisheries operations (i.e., the catching of fish, the carrying of crew and equipment to and from the fishing grounds, and the transport of the catch to port). If all of these functions are carried out by one vessel, technical efficiency has to be sacrificed to a certain extent, and operational costs are higher than when the functions are separated between different craft. In particular, processing facilities reduce the amount of space available for crew accommodation and transport of catches. Where warranted by the size of operations, arrangements for processing at sea are most satisfactory, therefore, if organized on a fleet basis, with catcher vessels, motherships processing the catches, and auxiliary craft delivering supplies and transporting to port products and crews entitled to vacations. Operations of this type are floating industrial complexes and are in a position to stay near the fishing grounds indefinitely or at least until major overhauls become necessary. Completely integrated fleets can, of course, only be maintained by enterprises with very considerable capital resources and are economically feasible only where the likelihood of maintaining operations at close to full capacity exists. Transfer of catches to motherships and operations on board in rough weather conditions are among the major difficulties encountered in processing at sea.

129. Compromise arrangements, combining processing with other functions on board the same vessel (necessary for operations conducted on a less ambitious scale) must solve such problems as providing adequate space for the processing ..

equipment as well as working space for the crews, including processing labour, and ensuring sufficient carrying capacity not only for catches and end products but also for water, fuel, etc. Where crews are kept at sea for extended periods of time, a serious morale problem arises. In the more advanced developed countries, high monetary incentives may have to be offered to induce crews to stay out at sea for several months. On the other hand, working conditions and crew accommodation as well as recreational facilities on large, well-equipped factory ships may be far superior to those found on the average off-shore fishing craft. These factors facilitate, in some instances, recruitment.

130. In recent years, the two most spectacular developments in fish processing at sea have been the rapid expansion of stern-fishing freezer-trawler operations and the organization, in the industries of the USSR and of Japan and, to a lesser extent, also of Spain, of fishing fleets with mothership and fish transport vessels. Salting aboard vessels in the western parts of the North Atlantic, and tuna-freezing on tune clippers and purse seiners, are other important examples of processing operations at sea as are whaling operations.

131. Processing at sea is uneconomical in most operations carried out at relatively short distances from shore. Exceptions are, perhaps, "mobile sea factories", where the establishment of shore plant appears impractical. The additional cost of a mobile factory over a shore plant may be offset by the possibility of extending the season or by the opportunity to exploit a resource which otherwise would not be utilized at all.

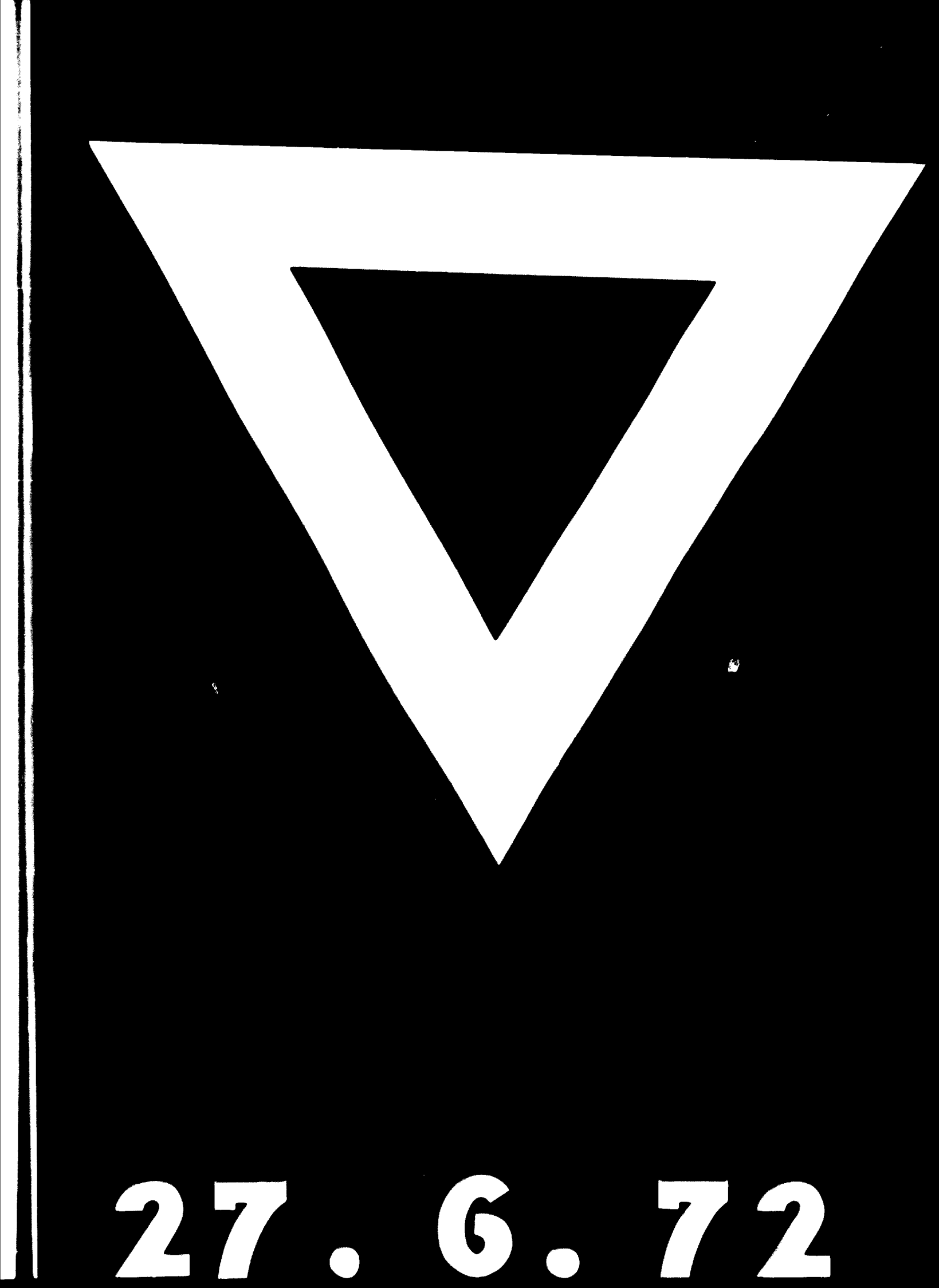
X. ANCILLARY FACILITIES

132. Modern fish catching and processing industries depend on the support of a great variety of ancillary facilities, the provision of which has stimulated the establishment of new industries. Fishing vessels and gear are the basic requisites for fish production.

133. The many innovations and improvements in fishing equipment and methods made in recent years have had far-reaching and varied results on the development of fishery industries. They have made it technically feasible to exploit resources which could not be fished at the previously existing stage of technology. This has led to an increase in catches and - sometimes also - to a lowering of costs of production and cheaper raw material prices. At the same time, also, however, technological progress has brought about an "internationalization" of fisheries and intensified competition in off-shore fisheries. In many developing countries, craft and other equipment and fishing methods which have proved successful in more advanced fisheries have been introduced and adapted with success to local conditions.

134. Aside from fishing boatyards and equipment manufacturing and sales firms, shore installations required for the operation of fishing fleets include landing facilities, vessel repair shops, fueling stations, ship stores, etc. Ice plants are essential for chilling and cold storage, both at sea and in conjunction with shore handling, processing, transport, and warehousing facilities.

135. Transport and warehousing facilities for fishery products as such must often be especially adapted to meet the requirements for handling products characterized by exceptional perishability and by strong odours factors which make the handling together with other foodstuffs difficult, if not impossible.



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